

A New Look at the Role of Disciplines in Citation Analysis

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Abstract

The increasing number of scientific journals, even in a subfield, necessitates a reliable and authoritative measure for researchers and libraries to identify core journals in a given subfield. The impact factor value is affected by different factors such as subject area, type of documents or length of the citation measurement window. In order to prioritize the choice of quality journals for scientists and libraries two new measures (Indices) have been developed. The DSI is an aid to decision-making with regards to the level of journal specialism within a particular discipline and serves to inform researchers in the field who wish to make individual subscription decisions. DPI has been proposed as a decision-making tool for libraries as it indicates the proportion of all citations within a particular discipline that have been received by a particular journal.

Keywords: Discipline Proportion (Share) Index, Discipline Specialism Index, Citation Analysis.

Introduction

The Impact Factors, as introduced by Garfield (1979), of about 7500 scientific journals in different specialized disciplines are readily available through the ISI. To overcome subscription funds limit, libraries tend to select journals with high Impact Factor (IF).

The impact factor for a journal is calculated based on a three-year period. It can be viewed as an approximation of the average number of citations in a year, given to those papers in a journal that were published during the two preceding years. For example, the 2003 impact factor for a journal would be calculated as follows:

A = number of times articles published in 2001-2 were cited in indexed journals during 2003

B = number of "citable items" (usually articles, reviews, proceedings or notes; not

editorials and letters-to-the-Editor) published in 2001-2

2003 impact factor = A/B

The IF of a journal is used in the literature as a measure of expected citations for each of the papers published in it that is an indirect measure or proxy of their quality and impact. However, this point is controversial among research performance evaluators.

The impact factor value is affected by different factors such as subject area, type of documents or length of the citation measurement window. Another critical comment about impact factor measures is that the distribution of citations within a journal is highly skewed, and a great percent of papers in a journal receive no citations at all. However, impact factor validity is supported by the strong negative correlation illustrated between the value of the IF and the degree of uncitedness of a journal's articles (Van Leeuwen & Moed, 2005). In other words, taking into account the rate of uncited articles in a given set of journals does affect their impact factor. Finally, a lack of correlation between observed and expected citations has been reported by different authors (Seglen, 1992). This is especially true for peripheral countries' papers, which are less cited than those of central countries. In connection with the above information, the following sections aim to describe methodological procedures, which have been undertaken to overcome some limitations of Isis's IF.

Problems over impact factor

Many studies have showed that a higher impact factor has been described for "reviews" than for other document types, and "basic research" receives higher impact factors than "applied science". Thus, research by Woodward & Sandy (1976) has shown that review journals tend to have higher impact factors. Van Raan (1987) developed a measure, termed "comparative impact," which graphically depicts the citation record for each type of publication in a journal, e.g., letters, editorials, and "normal" articles.

Moreover, the two-year citation window of the Journal Citation Report (JCR) IF is considered too short to detect the real impact of publications in "slow" evolving disciplines. On the other hand, impact factor compensates for the advantage that older, larger, or more frequently published journals would enjoy if rankings were based on total citations received. Scanlan (1987) has offered a harsh criticism of impact factor from the perspective of publishers, noting that the type and length of articles and a research field's size, style, and citation tradition, as well as journal self-citations can influence impact factor. In consequence, impact factors should be used with caution and comparisons should be limited to comparable units. The wide use of the IF, in spite of its weaknesses, has provoked information science researchers to seek to improve the algorithm for the calculation of the IF or to develop alternative journal citation measures altogether.

Modifications of journal rankings based on impact factor citation windows

Asai (1981), who introduced an Adjusted Impact Factor, found that more accurate statistics could be calculated provided that the period- count is based on months rather than a year. He proposed to count a weighted sum of citations per month over a time period of four years. Glänzel & Schoepflin (1995) found that the three-year citation window proved to be a good compromise between the fast obsolescence of technology- oriented literature of most areas in life sciences, and of experimental physics literature on the one hand, and of the slowly aging theoretical and mathematical topics in physics, on the other hand. The Cited Half-Life Impact Factor (CHAL-IF) of Sombatsompop, Markpin, Yochai & Saechiew (2004) is based on replacing the two-year citation window with the journal's cited half-life in the IF computation formula.

Modifications of journal rankings based on averaging impact factor

With regard to yearly fluctuations of journal ranking, Christenson & Sigelman (1985) averaged impact factor of 56 political science and 61 sociology journals for three years for the purpose of comparison with the subjective rankings of political science journals by Giles & Garand (2007) and sociology journals by Glenn (1971). Feingold (1989) averaged IF data from 1985 to 1986 and ranked 52 journals in eight subfields of social science psychology (each subfield journals were ranked). A similar approach was undertaken by Colson (1990) to rank 35 public administration journals to compensate for yearly fluctuation.

Whilst Garfield's Impact Factor ranks journals by the number of citations received, it does not take into account the field of study from which that citation has been received. Baldi & Hargens (1995) stated that the citation process could be considered a dynamic relationship between the citing and cited document. "A cited document cannot exist without the existence of a citing document." 'Citing documents' do not exist in a vacuum. They only have relevance when put into the context in which they cited. This context is absent in Garfield's Impact Factor measure / index.

When ranking a list of journals within a subject discipline, it is inadequate to only compare the IF without consideration of subject bias.

Modifications of journal rankings to overcome subject and field biases

Hirst (1978) introduced Disciplinary Impact Factor (DIF) to rank journals within a subject discipline. His idea is based on the average number of times a journal was cited in a sub-field rather than the entire SCI database. Since knowledge of the core journals is a prerequisite to determine the core journals of a given field, the result of different studies may differ due to the baseline of calculation. His formula is described as follows:

DIF=nc/ns, where nc is the number of citations of a given journal (J) by journals

determined as core(C) over a time period t_c and n_s is the number of citable items published by (J) over a time period t_s .

Vinkler (1987) introduced the “citation strategy indicator,” which relates a journal’s impact factor to the mean impact factor of other journals in its specialty. Vinkler (1991) also introduced a new indicator called “Standard Journal Impact” (SJI) as a comparable impact indicator for journals in different subfields. The SJI proposed by Vinkler “was based on the number of citations obtained in year Y, where the impact factor was calculated, to papers published in a single X year, prior to year Y, divided by the number of papers published in year X. The number of years used for SJI index was then calculated using a period which lasted from the maximum SJI value to its half” (Arongrit, 2004). He stated that the main reason for the lower impact factor journals was mainly caused by lower extent of the application of their results by other subfields.

Ramírez, Garcia & Rio (2000) proposed a renormalized IF which was calculated based on the maximum IF and median IF of each category. The applied methodology was taking from each category listed in the JCR, the maximum value of the impact factor and the median impact factor. For a given journal their renormalized impact factor formula was $F_c = (F - F_{med}) / (F_{max} - F_{med})$. The character c indicates that F_c is category dependent. In case of a given journal listed in more than one category, the following additional calculus was applied: $F_r = \sum F_{ci} / n$. F_{ci} is the indication of each category so that the sum is performed over the n categories where the journal was listed. This quantitative parameter allows the direct comparison among different research areas without introducing other considerations. The main limitation of F_r (Renormalized impact factor) is the absence of a lower bound, which made difficult for comparison between journals with $F_r = 0$.

Pudovkin & Garfield (2004) suggested a rank normalized impact factor to be calculated across subject categories as below:

“Rank-Normalized Impact Factor ($rnIF_j$) = $(K - R_j + 1) / K$, where R_j is the JCR rank of journal j and K is the number of journals in its specialty category.

Within each JCR category journals are always displayed in descending order. For example, the journal Genetics is the 17th from the top in the JCR category for Genetics & Heredity. In 2000, this category contained 114 journals. Thus, $rnIF_{Genetics} = (114 - 17 + 1) / 114 = 0.860$. The value of $rnIF$ is very easy to interpret: if a journal j has $rnIF_j = X$ it means that $100\% \times (1 - X)$ of the journals in its JCR category have higher IF values. So, for the journal Genetics 14% of the journals in its category have higher IFs. Under the suggested normalization the top journals in each subject category have $rnIF$ equal to 1.0 and the median journals will have $rnIF$ close to 0.5. When a journal is assigned by the JCR to two or more different categories we average the $rnIF$ values” (Pudovkin & Garfield, 2004).

Whilst the $rnIF$ can be used as a method of reducing bias between disciplines, it does not address the problem of differences within each discipline.

Similarly, the same problem was approached by Sombatsompop, Markpin, Yochai & Saechiew (2005) who introduced a new mathematical index, the "Impact Factor Point Average" with the specific aim to allow across-field comparison of IF.

Whilst measures allowing comparisons between disciplines are useful, they suffer from a number of drawbacks.

Whilst the number of citations received per article is a readily available measure, it does not provide any discipline-specific information that would allow the librarian to determine which of the journals within the field of e.g. Dermatology are used most often within that discipline.

Utilizing Garfield's Impact factor measure assumes that the citations received by a journal relate directly to its specialist discipline. However, in course of this study it became clear that this is an inadequate method and better measures need to be developed.

Economic constraints require libraries to prioritize their journal subscriptions. In order to best serve their clients, they need to maximize their usefulness whilst minimizing the number of journal titles purchased. For example, if a medical library serving a department specializing in Dermatology could determine that of the 29 journals serving this discipline, 4 titles receive 40% of all citations within the field of Dermatology; this would allow the library to maximize its return on purchases.

On the other hand, the impact factor would be less useful to an individual researcher in the Dermatology field since s/he is most likely to be looking for a journal that attracts a large proportion of readership from within the field of Dermatology.

At first glance, this may appear to be an academic distinction. However, it will be shown that when each of these perspectives is addressed separately, it can result in significantly different rankings in journals within a particular discipline.

Consider the following two fictitious journals. Journal A publishes ten articles per week on the subject of Pharmacology and Journal B publishes 10 articles per month on cardiovascular disease. Table 1 shows the Impact factor of these Journals based on the number of articles and the number of citations received.

Table 1

Impact Factor of Two Fictitious Journals

Journal	Articles published	Citations received	Impact Factor
Journal A	1040	1000	0.96
Journal B	240	500	2.08

On the face of it, based on their Impact Factors, it would appear that the quality of articles published in Journal B is superior to that published in Journal A. However, the latter has received twice as many citations as the former. Therefore, in absolute terms, over

the previous two years, Journal A has received twice as many citations, which could be argued to mean that it has been more influential, even though its Impact Factor is less than half of the journal B. However, the average quality of each article in the journal B may be considered to be greater than the journal A. In many cases, decision makers are interested in the overall influence of journals rather than the average quality of articles in those journals.

A useful analogy may be to compare countries per capita income (GDP) with their degree of international influence.

According to the World Bank in 2006 Luxemburg ranked first with a per capita income of \$102,000. The United States, on the other hand, ranked fourth with \$46,000 per capita. However, the Gross National Income (GNI) of these countries was \$42bn and \$13,194bn, ranking the 65th and first respectively.

Similarly, the number of citations received by a journal can be considered to be its level of influence, whilst the impact factor is similar to the per capita GDP, indicating the average number of citations per article.

From the above example, we conclude that factoring the number of articles per journal into a measure of journal quality can be misleading and may not be necessary. This argument is further developed below to justify the new index being introduced here. In order to prioritize the choice of quality journals for scientists and libraries, this paper proposes two new measures (Indices) to be taken into account by individual researcher when writing or submitting articles for publication and for libraries for subscription.

Development of Two Proposed Alternative Measures for Intra-Disciplinary Comparisons

The limitation of Garfield Impact Factor (GIF) being addressed in this study is in relation to the field of investigation (discipline) that is the main focus of an article. Using the above fictitious journals, Table 2 serves to illustrate the point.

Table 2

The Detail of Two Fictitious Journals

Journal A (Pharmacology)					
Article citation rankings	Articles published	Citations received	Impact Factor	Total Citations in field	The Discipline Proportion (Share) Index (DPI)
Cardiovascular Agents	400	700	1.75	2000	0.35
Endocrine Agents	430	200	0.47	400	0.5
Toxicology	210	100	0.48	300	0.33
Total	1040	1000	0.96		

Journal B (cardiovascular)					
Cardiovascular Agents	50	60	1.20	2000	0.03
Cardiovascular Diseases	90	350	3.89	10000	0.035
Cardiovascular Diagnosis	100	90	0.90	500	0.18
Total	240	500	2.08		

Both of the above journals share a common interest in the field of ‘cardiovascular agents.’ If we were to only consider the impact factor of these articles, Journal A would have a higher GIF in this discipline than journal B (1.75 vs. 1.20). However, Journal A’s articles on cardiovascular agents have received 700 citations in comparison to the 60 citations received by journal B. The newly developed index discussed in the following section addresses this issue. Later, the practical applications and implications of this measure are discussed.

The Discipline Proportion (Share) Index (DPI)

This index was conceived to address the lack of effective measures for the share of citations that a journal receives from articles in a particular discipline.

The DPI is defined as the proportion of the total citations to a particular discipline (from all journals) that is received by a particular journal:

<i>DPI =</i>	<i>Number of citations from a particular discipline received by articles in a particular journal from a given time period</i>
	<i>Total number of citations given to that discipline by all journals in the same time period</i>

Applications of DPI

The discipline of Dermatology (as an example) has been used here to illustrate the application and the merits of DPI. One of the advantages of this index is that the data that is required to calculate it are already available in the ISI database. The required data were retrieved from the online database of Web of knowledge on October 2007 for citations received for articles published from 2005 through 2006 by December 2007.

Table 3 shows a list of the 29 Journals that have been classified by ISI to belong to the Dermatology discipline along with data relating to their DPI.

Table 3

DPI-related Data (for Citations Received for Articles Published from 2005 through 2006 by December 2007) for the 29 Dermatology Journals (from ISI)

Journal	Number of Dermatology citations received (NDR)	DPI (% of All Dermatology citations)	Cumulative %	GIF
British journal of dermatology	1270	15.3%	15.3%	1.27
Journal of the American academy of dermatology	1100	13.3%	28.6%	0.64
Journal of investigative dermatology	998	12.0%	40.6%	0.67
Archives of dermatology	755	9.1%	49.8%	1.67
Dermatology	458	5.5%	55.3%	1.73
Dermatologic surgery	322	3.9%	59.2%	0.92
Journal of the European academy of dermatology and venereology	314	3.8%	63.0%	0.20
International journal of dermatology	305	3.7%	66.6%	0.79
Experimental dermatology	286	3.5%	70.1%	1.34
Clinical exp dermatology	274	3.3%	73.4%	0.93
Contact dermatitis	270	3.3%	76.7%	0.93
Journal of cutaneous pathology	187	2.3%	78.9%	0.81
Burns	182	2.2%	81.1%	1.00
Acta dermato-venereologica	171	2.1%	83.2%	0.78
J of dermatological sciences	169	2.0%	85.2%	1.89
European journal of dermatology	162	2.0%	87.2%	1.05
Journal of dermatology	156	1.9%	89.1%	0.61
Pediatric dermatology	155	1.9%	90.9%	0.77
American journal of dermatopathology	154	1.9%	92.8%	1.11
Cutis	103	1.2%	94.0%	0.56
Annales de dermatologie et de venereologie	81	1.0%	95.0%	0.20
Am j clinical dermatology	76	0.9%	95.9%	2.12
Clinics in dermatology	69	0.8%	96.8%	0.99
Hautarzt	67	0.8%	97.6%	0.31
Dermatologic clinics	63	0.8%	98.3%	1.24
Seminars in cutaneous medicine and surgery	49	0.6%	98.9%	1.10

Journal	Number of Dermatology citations received (NDR)	DPI (% of All Dermatology citations)	Cumulative %	GIF
Mycoses	43	0.5%	99.4%	1.27
Leprosy review	27	0.3%	99.8%	0.47
Journal of cutaneous medicine and surgery	20	0.2%	100.0%	0.33
Totals	8286	100%		

The above Table shows that using the DPI index, a librarian can determine that the top four journals have received almost 50% of all Dermatology citations. In other words, a library can provide 50% of the information needs of its Dermatology specialists by subscribing to only 4 of the 29 Journals classified as specializing in Dermatology.

Discipline Specialism Index (DSI)

This index was conceived to address the lack of effective measures for the extent to which the citations received by a journal reflect a particular specialism.

The DSI is defined as the proportion of the total citations to a particular journal which relates to articles in a particular discipline:

<i>DSI =</i>	<i>Number of citations from a particular discipline received by articles in a particular journal from a given time period</i>
	<i>Total number of citations given to that Journal in the same time period</i>

Applications of DSI

To allow comparison of this index with DPI, the discipline of Dermatology has again been used here to illustrate its applications and merits. Again, one of the advantages of this index is that the data that is required to calculate it are already available in the ISI database.

Table 4

DSI-related Data (for Citations Received for Articles Published from 2005 through 2006 by December 2007) for the 29 Dermatology Journals (from ISI)

Journal	Number of citation	Number of Dermatology citations received (NDR)	DSI (% of citations that are Dermatology)	GIF
Dermatology	648	458	70.7%	1.73
Cutis	157	103	65.6%	0.56
Pediatric dermatology	241	155	64.3%	0.77
Contact dermatitis	425	270	63.5%	0.93
Journal of cutaneous medicine and surgery	32	20	62.5%	0.33
Annales de dermatologie et de venerologie	132	81	61.4%	0.20
Seminars in cutaneous medicine and surgery	80	49	61.3%	1.10
American journal of dermatopathology	253	154	60.9%	1.11
Archives of dermatology	1241	755	60.8%	1.67
Journal of dermatology	258	156	60.5%	0.61
Journal of the european academy of dermatology and venerology	528	314	59.5%	0.78
Acta dermato-venereologica	292	171	58.6%	0.78
Journal of the american academy of dermatology	1966	1100	56.0%	0.64
European journal of dermatology	293	162	55.3%	1.05
Hautarzt	123	67	54.5%	0.31
Dermatologic surgery	609	322	52.9%	0.92
International journal of dermatology	578	305	52.8%	0.79
Clinical exp dermatology	521	274	52.6%	0.93
Leprosy review	53	27	50.9%	0.47
British journal of dermatology	2516	1270	50.5%	1.27
Journal of cutaneous pathology	417	187	44.8%	0.81
Clinics in dermatology	164	69	42.1%	0.99
Burns	434	182	41.9%	1.00
Experimental dermatology	688	286	41.6%	1.34
Dermatologic clinics	153	63	41.2%	1.24
Am j clinical dermatology	195	76	39.0%	2.12

Journal	Number of citation	Number of Dermatology citations received (NDR)	DSI (% of citations that are Dermatology)	GIF
J of dermatological science	497	169	34.0%	1.89
Journal of investigative dermatology	3014	998	33.1%	0.67
Mycoses	275	43	15.6%	1.27
Totals		8286		

The above Table shows that using the DSI index, an individual Dermatology specialist can identify those journals where the greatest proportion of citations received are to Dermatology-related articles.

Comparison of DSI, DPI and Garfield's Impact Factor

The most prolific use of Garfield's Impact Factor is for the ranking of Journals. The output of a comparison of the ranks of journals on the basis of these three indices using Spearman's Rank Correlation is shown in Table 5.

Table 5

Rank Correlation Analysis (Spearman's Rho) of the Three Indices

		DSI	DPI	GIF
DSI	Correlation Coefficient	1	-0.005	-0.355
	N	29	29	29
DPI	Correlation Coefficient	-0.005	1	0.199
	N	29	29	29
	Correlation Coefficient	-0.355	0.199	1
	N	29	29	29

The above Table reveals that there is no clear evidence of correlation between DSI and DPI or between GIF and either DPI or DSI. Therefore, it might be concluded that each of these three indices is measuring something different. As such, each should be used in the appropriate context in order to derive maximum value from citation data.

Conclusion

In this chapter, it has been argued that GIF is not a satisfactory decision-making tool in a number of important contexts. The influence of the field of study (or discipline) on the impact factor of journals has been highlighted. Although several previous researchers had pointed out this limitation and had suggested ways of correcting this, it has been shown

here that the previous indices were too complicated to be widely utilized by information services professionals and by researchers in the field. In addition, they did not address the two main problems of core specialist journal selection and the level of specialism of journals.

To address these shortcomings, two new measures (Indices) have been developed.

The DSI is an aid to decision-making with regards to the level of specialism of a journal within a particular discipline and serves to inform researchers in the field who wish to make individual subscription decisions.

DPI has been proposed as a decision-making tool for libraries as it indicates the proportion of all citations within a particular discipline that had been received by a particular journal.

The data required to calculate the values of these indices for each journal is readily available, making them easily accessible.

Whilst the DPI applied to the Dermatology journals as an example, appears to support Bradford's 20/80^[1] rule, through the use of DPI, it will be possible to determine which journals fall into the '20' category and which into the '80'.

Since based on the prior argument the number of article in the newly proposed indices was taken into account; therefore the size of field or subfield will not affect journal ranking. However, it is not surprising to see a significant correlation between the DPI ranking and the number of articles that a given journal publishes. Within the 29 dermatology journals with which this index was tested, the strength of the correlation ($r=0.85$) indicates that variations in the number of articles accounts for 73% (r^2) of the variation in the number of citations received. Here it is argued that, whereas GIF is a measure of the average quality of the articles published by a particular journal, the number of citations received within any particular discipline is a better indicator of a journal's influence than either the number of articles that it publishes or its GIF. As mentioned earlier, the proportion of review articles published by a given journal affects the rate of citations it receives; therefore, the inherent shortcoming of journal ranking based on citation is also present in the suggested indices.

Both of the newly-developed/proposed indices have been applied to actual data from ISI for the Dermatology discipline. The results have confirmed the usefulness of each and the need for two separate indices.

Endnote

1. Also known as the Pareto principle, the law of maldistribution, the law of the vital few and the principle of factor sparsity, the vital few and the trivial many, the 80/20 rule states that for many phenomena, 80% of the consequences stem from 20% of the causes. The principle was first suggested by management thinker Joseph M. Juran, who named it

after the Italian economist Vilfredo Pareto, who observed that 80% of income in Italy was received by 20% of the Italian population.

Source: Trueswell, R. (1969). Some behavioral patterns of library users. The 80/20 rule. *Wilson Library Bulletin*, 46, 458-461.

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